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DISEASES AND INSECT PESTS OF THE Raspberry IN CANADA

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DISEASES AND INSECT PESTS OF THE RASPBERRY

G. C. Chamberlain[1] and W. L. Putman[2]

Raspberry growing is an important enterprise in Canada with production averaging around 12 million quarts annually. The crop is produced mainly in British Columbia and Ontario, and to a lesser extent in Quebec, Nova Scotia, and New Brunswick. Raspberries are subject to diseases and insect pests that may seriously reduce production and quality if not controlled. This bulletin gives information that will help growers to recognize the more common diseases and pests and to apply appropriate control measures.

GENERAL RECOMMENDATIONS

Good cultural practices are important aids in combating raspberry disorders and insect pests. Often they are the most practical and, in some cases, the only control measures known.

In setting out a plantation, choose a site that is well drained and in an open location. Close planting should be avoided and the rows should not be allowed to become too wide or dense. Remove the old fruiting canes as soon as the fruit is harvested (except in coastal British Columbia). At the same time cut out surplus canes, weak ones, and those showing extensive lesions, scars, cracks, or swellings. It is also good practice to prune out any canes that do not leaf out normally in the spring. All prunings should be burned promptly.

Keep plantations free from weeds as these encourage infestations of insects and the development of cane diseases. Wild raspberries and blackberries and neglected patches of cultivated varieties are also prolific sources of insect pests and disease and should be removed from the vicinity of the plantation.

Raspberries should not be planted immediately after tomatoes, potatoes, eggplants, or peppers, as these crops may introduce the organism causing Verticillium wilt.

The use of straw mulch may favour the development of cane diseases. Sawdust is preferable to straw for mulch purposes.

The annual application of insecticidal or fungicidal sprays on raspberries is usually not necessary in most parts of Canada. However, in the event of unusual outbreaks or in districts or seasons particularly favourable to their development, spraying helps greatly to prevent losses. Growers are advised to watch their plantings and apply the suggested treatments promptly when outbreaks threaten. It is frequently feasible to have the sprays serve a dual purpose by combining an insecticide and a fungicide. It should be remembered, however, that raspberry foliage is extremely susceptible to spray injury and, therefore, only the materials known to be safe should be used.

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VIRUS DISEASES

Virus diseases are found throughout Canada on wild and cultivated raspberry varieties. They are the most important troubles affecting this crop, being responsible for the so-called "running-out" of plantations. These diseases are systemic, that is, the infective principle permeates all parts of affected plants. Such plants never recover and suffer a decline in vigour of growth and production year by year.

Virus diseases of raspberries are spread by plant lice or aphids. The infection is carried by these insects as they pass from diseased to healthy plants in the course of feeding.

Mosaic

There are two types of raspberry mosaic, green mosaic and yellow mosaic. These can be distinguished readily on black and purple raspberries, but only with great difficulty on red varieties. The diagnostic symptoms are discernible only on the foliage. The leaves do not wilt, dry up, or fall, but rather assume a somewhat lighter colour than the normal green of a healthy plant and become mottled and dwarfed (Fig. 1). Green mosaic is usually characterized by a true

Fig. 1.—Leaf mottling caused by mosaic.

mottle pattern of alternating yellowish or light green and blister-like dark green areas. The leaf discoloration of yellow mosaic, on the other hand, is typically a general yellowing of tissues, spreading from the veins outward and from the margin inward. Leaves affected with green mosaic are smaller than normal but not noticeably deformed. With yellow mosaic, the leaflets are still smaller and narrower and are cupped either downward or upward.

Dwarfing of cane may not be noticeable during the first year of infection but thereafter dwarfing becomes gradually more pronounced (Fig. 2). Fruit from mosaic plants is small, insipid, and tends to be crumbly.

Mosaic symptoms are particularly noticeable on the new growth in the early summer. Inspections, therefore, should be made about the first of June and should be repeated at intervals throughout the growing season. Symptoms are more definite and more readily discernible if the plants are shaded during inspection. Great care with the inspection is necessary since the mottling may be easily overlooked or confused with other disorders. When once mosaic occurs in a plantation, its spread can be successfully controlled only by removing affected stools as soon as they are detected.

Fig. 2.—Stunted growth caused by mosaic.

Leaf curl

Fortunately, this virus disease is not so prevalent nor widespread as mosaic. Affected bushes are worthless and should be destroyed without delay. The leaves on such plants are not mottled but are uniformly dark green in colour, small, and tightly curled down and inward (Fig. 3). The fruiting laterals are short and grow more upright than normal ones. The suckers from a diseased bush are severely dwarfed and terminate in a bunchy tip. The fruit is small, hard, seedy, and useless.

Yellow blotch curl

Stools affected with this disease lack vigour and appear thin and spindly. The canes exhibit an erect, stiff habit of growth and bear pale, chlorotic, lustreless foliage very suggestive of the effect expected either from a depleted soil or

from lack of adequate drainage. Shortening of the internodes and a loose downward and inward curling of the leaves crowd the leaflets together (Fig. 4). Frequently, a coarse, yellow blotching and spotting, often in definite rings, is found on basal leaflets. The stooling ability of affected plants is greatly diminished.

Control of Virus Diseases

1. The first step in the control of these diseases is the use of certified planting stock for setting out new plantations. Such stock is grown in accordance with certain regulations to ensure freedom from virus diseases and must be true to

Fig. 3.—Healthy Cuthbert cane (left) and leaf curl (right).

name and of good general vigour. A list of growers offering certified planting stock for sale is prepared annually and may be obtained on request from the provincial agricultural offices, or plant pathology laboratories of the Canada Department of Agriculture. In provinces where certified stock is not available, it would be advisable to arrange for an inspection of the source of plants to determine the prevalence of virus diseases.

2. Inspect carefully and rogue all diseased bushes during the first two years. It is not practical to rogue older plantations except for leaf curl, which should not be tolerated at any time. In roguing, dig out all the infected canes and their roots and remove them from the plantation before the foliage wilts. Otherwise the aphids on the infected plants are likely to move to healthy plants and thus spread the disease.

3. Gaps resulting from roguing should be kept free from all sucker growth for one year before they are reset with healthy plants.

4. It is advisable to isolate new plantings at least 500 feet from old fruiting plantations or from clumps of wild raspberries. It is also advisable to plant each variety in a block, well separated from other varieties.

5. Plantations should be renewed frequently. Some growers have adopted the practice of planting in successive years. In this way it is possible to maintain production while discarding the older plantings that have become unprofitable through the prevalence of virus diseases.

6. Although varieties are selected largely on their horticultural merits and for local requirements, some consideration should be given to their susceptibility to virus infection. In Ontario, the red varieties, Latham, Viking, Taylor, Chief,

Fig. 4—Cuthbert canes infected with yellow blotch curl virus.

Cuthbert, and Ottawa, are more susceptible than Newburgh, Washington, Madawaska, Rideau, and Trent. The Columbian is undoubtedly the most susceptible of the purple varieties. Cumberland and Plum Farmer, among the black raspberries, show high susceptibility.

FUNGUS DISEASES

Diseases of this type are caused by fungi invading plant tissues, either leaf, stem, fruit, or root, to produce leaf spots, stem lesions or rots. Whether these diseases may be important or not in any one season, depends to a great extent on environmental conditions, location, and general cultural practices.

Verticillium Wilt or Bluestem

Caused by *Verticillium albo-atrum* Reinke & Berth.

Verticillium wilt or "bluestem" is a disease affecting the roots and canes of both black and red raspberries, and is particularly severe on black varieties. The causal fungus inhabits the soil and attacks the plant through the root system and progresses into the cane, causing wilting and eventually death. The disease is generally more severe in poorly drained locations and in seasons characterized by cool, wet weather in the spring. Wilt is usually more serious in plantations one to four years old than in older established plantings. Viking and Cuthbert are the most susceptible of the red varieties. All commercial varieties of black raspberries show equal susceptibility.

Red raspberries sucker freely and, although the infected cane dies, the stool can survive through the escape of shoots arising a little distance away from the centre of infection. On the other hand, black raspberries do not sucker and infected plants die.

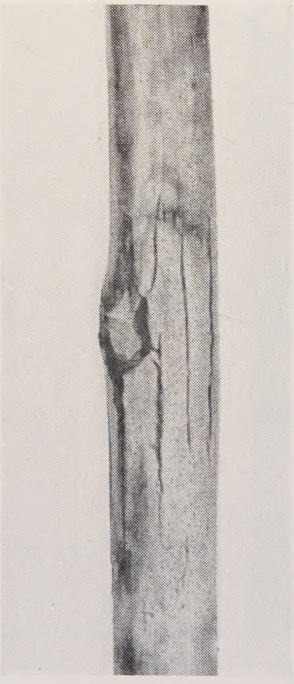

Fig. 5.—Appearance of spur blight on fruiting cane.

Symptoms.—The first symptom is a yellowing and wilting of the lower leaflets. This wilting, followed by the casting of the leaflets, progresses from the ground upward. Finally the cane becomes bare except for a tuft of small brownish leaves at the tip (Fig. 6) which may remain for a considerable time. At the time of the wilting and casting of the leaves, the cane generally assumes a blue coloration, which gives rise to the name "bluestem." This coloration may take the form of a stripe or stripes starting from the ground level and following the upward progress of the defoliation or it may cover the entire surface of the cane. Although the blue coloration is usually characteristic, the important and constant symptoms are the yellowing, wilting, and casting of the leaflets.

Control.—Select a well drained location for the new plantation.

Raspberries should not follow in soil that has been planted recently to tomatoes, potatoes, peppers, or eggplants. Furthermore, these crops should not be interplanted with raspberries. Such crops are susceptible to Verticillium wilt and may introduce the fungus into the soil, where it may live for four or five years.

Infected plants should be destroyed. Cutting out the diseased canes of red varieties will suffice. It is necessary, however, to rogue infected black raspberries. Do not replant rogued areas.

Spur Blight

Caused by *Didymella applanata* (Niessl) Sacc.

This disease is common and widespread on all varieties of red raspberries. In Ontario, the Latham, Madawaska, and Taylor are outstandingly susceptible. The greatest injury occurs to the buds, which may be greatly weakened or killed. Since the buds produce fruiting laterals the following year, serious spur blight infection reduces the crop.

Symptoms.—The first symptoms of spur blight appear on the lower part of the young canes as violet-brown to brown discoloured areas surrounding the point of attachment of the leaves (Fig. 7). These spots vary considerably in size and frequently coalesce to involve extensive areas and may be very conspicuous.

On fruiting canes, the diseased portion assumes a greyish coloration and numerous black "pimples" or fruiting bodies may be detected over the grey surface (Fig. 5).

The infection on the foliage occurs in the form of conspicuous brown lesions, mostly associated with the main veins. The brown lesions later turn black and affected leaves may drop.

Control.—Secure planting stock free from disease.

Select sites with well drained soil and good air circulation.

Fig. 6.—Defoliation of Cuthbert cane affected with Verticillium wilt.

Provide good aeration by thinning out the rows, practising clean cultivation, and removing weeds and surplus canes from within the rows. Do not allow the rows to become too wide or dense.

Roguing severely blighted canes during pruning operations is recommended.

Additional control is provided by spraying: (1) at the delayed dormant stage or as soon as buds show $\frac{1}{4}$ to $\frac{1}{2}$ inch of green tissue, with lime sulphur 10 gal. in water to make 100 gal. or 1 per cent Elgetol or Dinitrosol (4 Imperial quarts to 100 gal. water); (2) just before blossoms open, with bordeaux 5-5-100, or ferbam 2 lb. to 100 gal.; and (3) immediately after harvest and removal of old fruiting wood, with the same spray as in the second application.

Anthracnose

Caused by *Elsinoe veneta* (Burkh.) Jenkins

This disease affects both red and black raspberries. It is generally more severe on black raspberries, although recently it has become common on some red varieties.

Symptoms.—The disease occurs most commonly on the canes in the form of small greyish to whitish round spots with a purplish border (Fig. 8). The spots vary in size from $\frac{1}{8}$ inch in diameter to larger irregular blotchy patches where

Fig. 7.—Purple-brown lesions on young canes caused by spur blight.

two or more spots run together. Frequently the bark cracks in the affected area. In severely diseased canes, the tissues tend to dry out, with the result that fruit fails to develop to its normal size.

Similar but less conspicuous spots are present on the leaves. Often the infected leaf tissue drops out, leaving a "shot-hole" effect. Leaf and fruit stalks and fruit may also be affected with this disease.

Control.—Secure planting stock free from the disease. With black raspberries, remove and burn all old parts that remain above the ground after planting.

Select an open, adequately aerated location.

Thin out the rows to improve aeration, removing canes most heavily infected or weakened by anthracnose.

Clean cultivation is recommended. If weeds are permitted to grow, conditions become more favourable for the disease. Mulching has been found to encourage anthracnose development. Where this is done, a sawdust mulch is preferable to a hay or straw mulch.

Spraying as outlined under spur blight, effectively controls anthracnose.

Cane Blight

Caused by *Leptosphaeria coniothyrium* (Fckl.) Sacc.

This disease is of minor importance in well kept plantations. Infection occurs commonly through wounds caused by insects or damage by other agencies and frequently follows anthracnose and spur blight.

Symptoms.—The characteristic symptom of the disease is a sudden wilting and dying of the foliage of fruiting canes in the period between blossoming and fruiting. On such canes, a cankered area several inches long and smoky grey in colour is present. Many small black fruiting bodies of the fungus are scattered over the surface of the infected area.

Fig. 8.—Anthracnose spotting on black raspberry canes.

Control.—Control of the disease depends on keeping the plants free from injuries. The adoption of cultural practices to encourage good vigour of growth and winter hardiness along with control measures to reduce the incidence of cane diseases and insect pests will aid in preventing cane blight.

Botrytis Cane Wilt

Caused by *Botrytis cinerea* Pers.

This disease assumes importance in wet seasons in plantations where there is a dense growth of cane. In Nova Scotia, where it has become established, it is responsible for considerable killing of the canes.

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Symptoms.—In the fall, affected new canes have numerous black bodies or sclerotia, $\frac{1}{16}$ inch wide and from $\frac{1}{4}$ to $\frac{1}{2}$ inch long, scattered along the bark immediately beneath the epidermis. In the spring, the sclerotia break through the epidermis and fall to the ground. A grey fungus growth may be seen on these bodies at this time. Later in the spring, infection of the new canes occurs, causing the tips to wilt and die.

Control.—Cut out and destroy affected canes when found. A careful examination of the canes should be made at the time of the main pruning operation and all new canes bearing the black bodies or sclerotia should be removed and destroyed. Mulching and permitting the rows to become too thick have been found to favour the disease.

Fig. 9.—Leaf spot infection.

Powdery Mildew

Caused by *Sphaerotheca humuli* (DC.) Burr.

Powdery mildew affects most varieties of raspberries. The disease is frequently epidemic on the red raspberry variety Latham, which is particularly susceptible.

Symptoms.—The most striking symptom is the dwarfing of leaves and stunting of the terminal growth. The latter is referred to as "rat-tail", because of the slender tips and small leaves. Mildew produces a distinct mottle on the tip leaves similar to that associated with mosaic, and it is sometimes difficult to distinguish between the two diseases. The presence of the white powdery growth of the fungus, particularly on the lower surface of affected leaves, is diagnostic for this disease.

Control.—There is no satisfactory control measure. It is important to select locations with well drained soil and good air circulation. Avoid close planting and thick wide rows. Canes showing "rat-tail" tips should be pruned well back. In propagative beds, clean-digging or the removal of all hardwood cane is strongly recommended.

Leaf Spot

Caused by *Mycosphaerella rubi* Roark (*Septoria rubi* West.)

In some seasons this disease is prevalent and may cause partial defoliation. The infection occurs on leaves and leaf petioles and sometimes on flower pedicels.

Symptoms.—Small, circular reddish spots appear on the foliage (Fig. 9). The centre of the spots become greyish and minute black fruiting bodies appear. When the spots are numerous, the leaves turn yellow and drop. The disease is generally most conspicuous on the lower leaflets in the latter part of the season.

Leaf spot should not be confused with anthracnose infection on the leaves and petioles. The latter is distinguished by the purplish border of the spots.

Control.—The disease is rarely serious enough to justify special control measures. Avoid close planting and thick wide rows. Adopt cultural practices that promote good, vigorous growth.

Late Yellow Rust

Caused by *Pucciniastrum americanum* (Farl.) *Arth.*

Yellow Rust

Caused by *Phragmidium rubi-idaei* (DC) Karst.

Two similar rust diseases occur on raspberries, often causing considerable damage. The infections occur on leaves, leaf petioles, flower pedicels, fruit, and canes. These diseases are responsible for considerable premature defoliation, particularly in wet seasons, which favour their development. The variety Viking is outstandingly susceptible to late yellow rust and is the most seriously affected of the commercial varieties. Cuthbert, Washington, and Viking are susceptible to the yellow rust (*P. rubi-idaei*); the Latham, Newburgh, and Willamette show resistance.

Symptoms.—Yellow spots appear on the leaf tissues at any time during the growing season. These eventually develop a dusty yellow appearance. The infected leaves, especially those on the lower part of the cane, turn yellow and drop. This defoliation may be severe enough to prevent the crop from ripening properly. Black spots appear during the autumn on the underside of affected leaves. Yellow-coloured spore masses also occur on the fruit and may be present on the leaves in the fall.

Yellow rust may also occur on the basal portions of the canes as small lesions bearing the yellow spore pustules (Fig. 11).

Control.—Sanitation directed towards the destruction of infected leaves greatly reduces the source of infection. Late fall or early spring ploughing is recommended as an effective measure. Old fruiting canes and stubs should be cut at ground level.

Where conditions warrant, use the spray schedule recommended for spur blight.

Orange Rust

Caused by *Gymnoconia peckiana* (Howe) Trotter

This disease affects the blackberry, and occasionally the black raspberry, but not the red or purple varieties. It is a serious disease because affected plants produce no fruit and, since the infection is systemic, diseased plants never recover.

Symptoms.—Diseased plants produce an abnormally large number of stunted shoots lacking spines. These shoots exhibit a bunchy, upright habit of growth. White blister-like pustules appear on the under surface of the leaves, and these later break open and expose masses of bright orange-coloured spores. When a plant becomes infected, the fungus invades all the tissues, including the crown, and will attack new shoots year after year.

Fig. 10.—Crown gall on Columbian cane.

Control.—Rogue and destroy diseased plants in the early spring before the leaf blisters burst and expose the orange spores. Destroy wild black raspberry and blackberry plants in the vicinity of the plantation. The Lowden variety of blackberry has so far shown resistance to this disease.

Dry Berry

Caused by *Haplosphaeria deformans* **Syd.**

This is a disease of special importance in districts of British Columbia, where it causes considerable damage.

Symptoms.—Affected fruits remain small and dry and are of little value. Either the entire fruit or only a few drupelets may be blighted and turn brown. Fruits that have been partially blighted are malformed.

Control.—The most satisfactory control measure is the replacing of susceptible varieties. The Washington, Cuthbert, Latham, Newburgh, and Viking varieties are resistant; Lloyd George, Franconia, Antwerp, and Tahoma are susceptible. The loganberry is also susceptible.

Where susceptible varieties are grown, a dormant spray of lime sulphur 10 gal. to 100 gal. water, or dinitrocresol according to manufacturer's directions, is suggested.

The disease is less troublesome in areas of low humidity and where air drainage is adequate.

Crown and Root Rots

Associated with various soil-inhabiting organisms

The raspberry is subject to root-rots with which several soil-inhabiting organisms have been associated. Unfavourable soil factors, especially poor drainage, predispose the roots to attack by these organisms.

Fig. 11.—Yellow rust pustules on Cuthbert cane.

Symptoms.—Affected plants show a lack of vigour, dwarfing of growth, poor colour, and a scorching of leaves. Such plants show a lack of fibrous roots and the presence of discoloured roots with many brown to black necrotic lesions. Mushroom growths may be found about the crown of affected plants.

Control.—Provisions for good drainage and the maintenance of soil fertility are recommended. Raspberries should not be planted on newly cleared land because of the danger of mushroom root-rot.

BACTERIAL DISEASES

Crown Gall

Caused by *Agrobacterium tumefaciens* (E. F. Sm. & Towns.) Conn

Crown gall is the only serious bacterial disease affecting raspberries. It also attacks a wide variety of other plants. The causal organism inhabits the soil in

which it may persist for a number of years. Infection occurs through injuries to the roots or crown. The disease is prevalent and widespread in Ontario and particularly troublesome in nursery plantations.

Symptoms.—Crown gall is apparent as rough swellings or tumour-like warts on the crown and underground parts of the plant. The galls are at first whitish and later brown, and may vary greatly in size from $\frac{1}{8}$ inch to three or four inches in diameter (Fig. 10). Aerial galls may occur on black and purple varieties and appear as rough excrescences along the side of the cane.

Control.—Do not set out plants having galls on the roots or crown.

Do not plant raspberries in fields known to be infected with crown gall. Practise a 3-year crop rotation, using such non-susceptible crops as corn, oats, and wheat to precede raspberries.

Avoid injury to the roots and crowns when planting, cultivating, or hoeing.

The effect of crown gall may be minimized to a great extent by judicious fertilization and good cultural practices to encourage vigorous growth.

NON-PARASITIC TROUBLES

In addition to the diseases already described, there is a fourth group of disorders commonly called functional or physiological diseases. These disorders are caused by environmental conditions unfavourable for growth.

Winter injury—Winter injury is a convenient term applied to a group of disorders that originate or appear to originate during the dormant season. The effects of winter injury may appear in several forms attributable to a combination of factors. A few examples may be given: either low winter temperatures or cold drying winds may cause death of buds or canes; alternate spells of cold and mild weather during the winter may result in breaking the rest period and be followed by injury; late season immaturity may be a factor in the development of die-back of tips and branches; and excessive autumnal or spring soil moisture cause crown or root injury, which is manifested by sudden wilting and dying of spur growth in early summer.

Resistance to low temperature is an inherent character of some varieties of raspberries and should be kept in mind when selecting a variety for a particular location. For instance, under Ontario conditions, Latham and Chief show more resistance than other varieties of red raspberries and are to be preferred for colder districts in the province.

Late season immaturity predisposes the canes to injury during the winter. Prolonged cultivation or excessive fertilization followed by a late growing season, especially in districts of moderate temperature, contribute to winter injuries. For this reason, cultivation should be discontinued in late July or early August and a cover crop sown to check growth and harden the wood. The practice of cutting back the canes in late summer tends to encourage late growth and should be avoided. For the same reason, excessive fertilization, especially with nitrogen, should be avoided.

Drying winds and late spring frosts after the buds have broken dormancy also are factors resulting in injury to canes. It is desirable therefore, whenever possible, to choose a site providing some protection against the prevailing winds and to avoid low areas.

Poor drainage.—Raspberries require abundant soil moisture but are not tolerant of excessively wet conditions. Where drainage is lacking the roots suffer, crowns are weakened and, consequently, the cane growth lacks vigour, the foliage turns yellow, wilts, and may die before harvest. If natural drainage is lacking, it may be improved by the use of ditches and tile drains.

Fertility—Unthrifty growth, pale colour, and marginal scorch of foliage are manifestations of lack of nutrients or an unbalanced fertility level in the soil. If such conditions are encountered, an analysis of the soil should be obtained and the proper fertilizers applied to correct the deficiency.

Fig. 12.—Injury to fruit buds by adult raspberry fruitworms.

INSECTS ATTACKING THE RASPBERRY

Raspberry Fruitworms

Byturus spp.

The western raspberry fruitworm, *Byturus bakeri* Barber, is a serious pest of raspberries and loganberries in the lower Fraser Valley in British Columbia. The eastern raspberry fruitworm, *Byturus rubi* Barber, occurs in Eastern Canada but only occasionally causes much injury. A species of raspberry fruitworm is found in the Prairie Provinces, and has been reported as injurious in Saskatchewan. All species are very similar in appearance and habits.

Injury.—Fruitworm injury is of two types: (1) In the spring, the adult beetles skeletonize the young unfolding leaves and destroy the blossom clusters and later eat holes in the expanding blossom buds (Fig. 12). In severe infestations this causes a marked reduction in the set of fruit. (2) The small larvae, or worms, feed within the flower buds and then penetrate into the developing fruit. In raspberries they are generally found lying between the receptacle, or 'core', and the berry, but in blackberries and loganberries they remain within the picked fruit and make it unsaleable. Infested berries frequently shrivel or may decay or drop before harvest.

Habits and Life-History.—The adult beetles (Fig. 13) are elongate-oval and about one-sixth of an inch in length, yellowish-brown in colour and covered with fine short hairs. They emerge from the soil during the latter part of April in British Columbia or in May in Eastern Canada, when the raspberry buds are

beginning to grow. They feed on the expanding leaves and blossoms and lay eggs on or near the blossom clusters and later on the green berries. On hatching, the young larvae enter the blossoms or young fruits, where they feed on the fleshy receptacle. When fully grown they are elongate, about one-third of an inch in

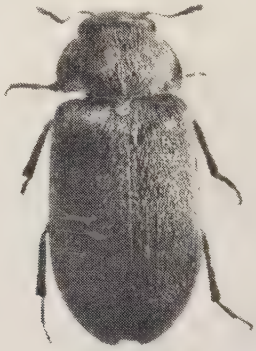

Fig. 13.—Adult of a raspberry fruitworm.
Enlarged about 17 times.

length, and yellowish-white in colour with a row of brown plates along the back. The mature larvae drop and burrow under the surface of the soil where they enter the pupal stage. The pupae transform to adults during the summer but the latter remain in the soil until the following spring.

Control.—In British Columbia, the recommended method of control is to apply sprays or dusts containing derris or cube (rotenone) to kill the beetles before they lay their eggs. Two applications should be made, the first during the latter part of April or early May when the blossom buds are separating in the cluster, and the second about three weeks later, just before bloom. For spraying, 3 lb. of powdered derris or cube root (containing 4 per cent rotenone), plus $\frac{1}{4}$ lb. of soybean flour or other neutral spreader, should be used in 100 gal. of water. For dusting purposes, commercial preparations that contain 0·75 to 1·0 per cent rotenone are obtainable.

DDT will also give good control, either as a 3 per cent dust or as a spray containing $1\frac{1}{2}$ lb. of 50 per cent spray powder per 100 gal. of water. However, in some areas, the use of DDT is liable to cause an increase of spider mites, which are very destructive and difficult to control.

In Eastern Canada, the methods recommended for British Columbia may be followed. When derris or cube is used it is usually applied at 5 lb. per 100 gal. The usual method of control practised in Ontario is to spray, as soon as the beetles appear, with lead arsenate at 5 lb. in 100 gal. of bordeaux 5-5-100, or lead arsenate at 5 lb. plus hydrated lime 5 lb. in 100 gal. of water. The spraying should be done from the top of the tank with good pressure to drive the spray down into the expanding new growth.

The Strawberry Leaf Beetle

Paria canella (Fab.)

The strawberry leaf beetle is an occasional pest of raspberries in Ontario and Quebec.

Injury.—The adult beetles attack the bursting buds in the spring, destroying them or riddling the young leaves. When they occur in large numbers the beetles may destroy all the buds and cause the death of the canes.

Habits and Life-History.—The adults are shiny, dark brown or black, oval beetles about one-eighth of an inch in length. They spend the winter under fallen leaves, sod, or debris in waste land, woodlands, and strawberry plantations. In the spring they emerge and attack the foliage of various plants. The eggs are laid in the soil and the larvae feed upon roots.

Control.—As soon as the injury is noticed, the plantation should be sprayed thoroughly with either lead arsenate at 5 lb. in bordeaux 5-5-100, or with lead arsenate at 5 lb. and hydrated lime at 5 lb. in 100 gal. of water.

The Strawberry Weevil

Anthonomus signatus (Say)

The strawberry weevil is a well-known pest of strawberries that occasionally attacks raspberries in Eastern Canada. It is seldom of importance except in New Brunswick, where it causes serious damage in some areas.

Injury.—The adult weevils cut through the stems of the blossom buds, causing them to wilt and drop off or to hang by a thread.

Habits and Life-History.—The adults are very small reddish-brown or blackish snout beetles about one-tenth of an inch long. They pass the winter under fallen leaves and rubbish in the plantation or in nearby woods or waste land. When the blossom buds are forming in the spring, the female lays an egg within the bud and then cuts the stem just below the bud so that it either falls immediately or is left hanging by a shred of tissue. The larvae develop in the fallen buds on the ground and the adults emerge in late summer.

Control.—A dust containing 30 parts of cryolite and 70 parts of pyrophyllite, or one containing 3 per cent DDT, is very effective when applied as soon as injury to the buds is noticed. As the cryolite dust is readily washed off by rains, the DDT dust may be preferable. From 40 to 50 lb. of the dust should be applied per acre.

The Oblique-Banded Leaf Roller

Archips rosaceana (Harr).

The oblique-banded leaf roller is widely distributed in Canada but is a pest of raspberries chiefly in British Columbia. In most seasons it causes little damage but occasionally it may occur in outbreak numbers. It also attacks many other plants.

Another leaf roller, *Sparganothis sulfureana* (Clem.) has been found attacking raspberry foliage in Ontario, but it has never been of any importance.

Injury.—The slender green caterpillars fold the leaves together or web the tips of growing shoots and feed within the shelter thus formed. The most serious injury is caused by the caterpillars feeding on the fruit; often they crawl between the receptacle and the berry.

Habits and Life-History.—The immature larvae, about one-eighth of an inch long, overwinter in silken cocoons under the bark and bud scales. In the spring they emerge and feed on the foliage, becoming mature in June. They are very active, slender caterpillars about an inch long and bright green with brown or black heads. They pupate within the folded leaves. The moths have a wing expanse of about an inch, and are reddish brown with oblique darker bands across the wings. They emerge in late June and July and lay their eggs on the leaves. The following brood of larvae feeds on both the foliage and fruit; it is this brood that is most injurious. Most of these larvae mature the same season and produce another brood of moths in September. The larvae hatching from eggs laid by these moths feed for a time on the undersides of the leaves and then spin their hibernation cocoons on the canes.

Control.—As about 75 per cent of the overwintering larvae are found on the old canes, removing and burning these canes between November 1 and March 1 will reduce the infestation greatly.

Where the infestation is severe, the plants should be dusted with 5 per cent DDT dust, or sprayed with DDT, 50 per cent wettable powder, at 1½ lb. per 100 gal. of water. This treatment should be applied during mid-May, when most of the caterpillars have emerged from their overwintering cocoons.

The Raspberry Bud Moth

Lampronia rubiella (Bjerk.)

The raspberry bud moth, a European pest, was discovered some years ago injurying raspberries in New Brunswick, and is also known to occur in Prince Edward Island. It has not caused any serious damage in recent years.

Injury.—The larvae bore into and destroy the swelling buds in the spring. Infested plantations have a thin and unhealthy appearance, suggestive of lack of fertilizer.

Habits and Life-History.—The life-history in Canada is not fully known. The very small, brilliant red caterpillars emerge from the soil in late April and early May and enter the expanding buds. They pupate in early June and the tiny moths, black with yellow spots, emerge about two weeks later. The young larvae feed in the receptacles of the fruit; later they apparently drop to the ground where they overwinter.

Control.—Little work on the control of this pest has been done in Canada. A certain degree of control was obtained in one year's experiments from a dormant application of an emulsion containing 2 per cent lubricating oil and 4 per cent dinitro-o-cyclohexylphenol.

Tarnished Plant Bug

Lygus oblineatus (Say)

The tarnished plant bug is a common insect that sometimes injures raspberries in Quebec.

Injury.—The adults puncture the blossom buds, causing mis-shapen berries.

Habits and Life-History.—The adults are about one-quarter of an inch in length and light brown in colour with black and yellowish markings. They overwinter under leaves and debris and emerge in the spring to feed upon and to lay their eggs in a great variety of plants. There are at least two generations each season.

Control.—Keeping the plantations and their surroundings free of weeds will aid in preventing injury. A spray of DDT, 50 per cent, at 2 lb. per 100 gal. of water immediately before the blossom period will give considerable control.

Cutworms

Various kinds of cutworms may attack the young shoots in the spring. They are large smooth caterpillars that feed on the foliage at night and hide in the soil in the daytime.

Fig. 16.—Larvae of the raspberry sawfly feeding on foliage.

Control.—Cutworms may be controlled by applying the following poisoned bait as soon as injury is noticed:

Bran	25 lb.
Paris green	½ lb.
Water	about 2½ gal.

The bran and paris green should first be mixed thoroughly in a tub; the water is then added slowly while the mixture is stirred. The bait is scattered thinly on the ground after sundown, along the rows where the cutworms are present. It is important that the bait be applied in the evening and only following a warm day.

The Raspberry Sawfly

Monophadnoides geniculatus (Htg.)

The raspberry sawfly is one of the commoner pests of raspberries in Eastern Canada and at times may cause considerable damage.

Injury.—The spiny, pale green larvae, about half an inch long when full-grown, feed upon the leaves (Fig. 16). When young they usually feed along the outer edges of the leaves but as they grow older they eat out irregular holes. In heavy infestations all of the leaf, except the larger veins, may be destroyed.

Habits and Life-History.—The adults are black, four-winged flies, which appear in May and June and insert their eggs within the tissue of the leaves. On hatching, the larvae feed on the foliage; when fully grown they drop to the ground and spin cocoons in the soil, where they pass the winter. In the spring they pupate and the adults soon emerge.

Control.—Raspberry plantations subject to the attack of the sawfly, and particularly those defoliated or partially defoliated the preceding year, should be sprayed, before the earliest blossoms open, with lead arsenate at 2½ lb. and hydrated lime at 5 lb. in 100 gal. of water. The lead arsenate may be combined with bordeaux mixture 5-5-100. Should the infestation not be noticed until after the fruit is set, commercial pyrethrum or derris (rotenone) dusts or sprays should be applied according to the manufacturer's directions. Arsenicals must not be employed after the pre-blossom stage because of the danger of poisoning the fruit.

The Rose Chafer

Macrodactylus subspinosus (F.)

In parts of southern Ontario with light, sandy soil, the rose chafer may be very destructive to raspberries.

Injury.—The adults, slender, long-legged, fawn-coloured beetles about three-quarters of an inch long, feed on the leaves and blossoms in June and early July. When abundant they may strip the plants.

Habits and Life-History.—The rose chafer passes the winter in the grub stage in the soil, 6 to 18 inches below the surface. In the spring the grubs come near the surface and feed on the roots of grasses and other plants and, in due course, transform to pupae and later to adults. Usually the beetles begin to emerge from the soil early in June, and continue to emerge for about one month, the majority appearing during the first two weeks. Eggs are laid only in sandy soil, most commonly in grass lands and grain fields, and to a lesser extent in graperies and other cultivated areas. The larvae feed on the roots of grasses, grains, and weeds throughout the summer.

Control.—Control of the rose chafer is essentially a matter of clean farming. The insect breeds only in light sandy soil and its most important breeding grounds are sandy waste land, such as idle farms and vacant fields or lots. Consequently the most important step in fighting this pest is the reduction of these favourite breeding grounds to a minimum. This may be done by bringing them under cultivation, or by seeding them to alfalfa or sweet clover, or by reforestation. In addition to the reclamation of waste sandy land, old fence-rows should be broken up and vineyards, orchards, and small-fruit patches should be kept well cultivated. Cultivated crops such as corn, potatoes, and strawberries should be grown to the greatest possible extent on the land surrounding the plantations. A short rotation of crops should be practised, with clover wholly replacing grasses.

It should be emphasized that the plough, disk and cultivator can be used most effectively in rose chafer breeding grounds at three different times; (1) in late May and early June, about the time the land should be prepared for the planting of corn and potatoes: (2) in mid-July, when the land should be prepared for buckwheat and when old strawberry patches should be ploughed under; and (3) in late fall, when ploughing is commonly done.

Grasshoppers

When grasshoppers are abundant they readily attack raspberry canes and may defoliate them completely. Nearly all of the feeding is done on bearing canes, so that the crop may be considerably reduced.

Control.—The area around the plantation should be sprayed with chlordane, 50 per cent wettable powder, at 2 lb. per 100 gal. of water, or dusted with 5 per cent chlordane dust. Aldrin may be used at half the rate recommended for chlordane. These sprays or dusts should not be applied to raspberries, other food crops or pastures.

Spider Mites

Spider mites, commonly known as 'red spiders', are among the most troublesome pests of raspberries. The two-spotted spider mite, *Tetranychus bimaculatus* Harvey, occurs in practically all raspberry-growing areas. The Pacific mite, *Tetranychus pacificus* (McG.), is troublesome in the Prairie Provinces and British Columbia. Another species, *Eotetranychus mcdanieli* McG., has been found on raspberries in Manitoba. All these species are similar in most respects.

Injury.—Injury is first apparent as very fine whitish or yellowish speckling on the foliage. This is caused by the mites sucking out the juices giving the foliage a pale, unhealthy appearance. Later the leaves may turn brown and drop. The undersides of the leaves are covered with a fine silken web, beneath which the mites may be seen as tiny moving dots. Injury is usually most severe in hot, dry weather.

Habits and Life-History.—The adult mites are about one-fiftieth of an inch long; during most of the season they are a pale greenish yellow but in the fall or on badly injured foliage they may be orange red. They overwinter under trash and in the soil about the bases of the canes. When growth starts in the spring they crawl up to the leaves and commence to lay eggs on the undersides. The mites that hatch from these eggs mature rapidly in warm, dry weather and in turn lay eggs that produce more mites. There may be as many as ten generations a year in the warmer parts of Canada.

Control.—Spraying with a 1 per cent summer oil emulsion, plus $2\frac{1}{2}$ lb. of soap per 100 gal., will destroy all stages of the mites hit by the spray. The spray should be applied thoroughly and directly at the undersides of the leaves, where the mites occur. Oil sprays should never be applied when the plants have been seriously injured by the mites nor when it is very hot, as the oil may injure the foliage under such conditions. To be sure of controlling the mites before injury occurs, the lower leaves on the canes should be examined shortly after the buds open. If mites are easily found, or if the leaves show spotting from their feeding, the plants should be sprayed immediately.

A number of new materials are known to give effective control of spider mites on other plants but they should not be used on raspberries until they have been thoroughly tested, because raspberry foliage is easily injured by spray materials.

DDT is very destructive to the natural enemies that usually keep spider mites under control. The use of this insecticide against other pests may therefore cause outbreaks of the mites. DDT should not be used on raspberries in districts where these mites are often troublesome, as in southern Ontario.

The Bramble Leafhopper

Typhlocyba tenerrima H.-S.

The bramble leafhopper is a major pest of raspberries and other cane fruits in the coastal areas of British Columbia. It is a European insect only recently discovered in North America.

Injury.—The nymphs feed on the undersides of the newly developing leaves, sucking out the plant juices. Later in the season both adults and nymphs attack the leaves, producing small, whitish spots or mottled areas on them (Fig. 14). These injured areas increase in size until the entire leaf becomes pale greenish yellow, the canes show little vigour, and the foliage presents a general withered appearance. In a severe infestation during a dry season, all the leaves have a curled, burned appearance, and as a result the fruit fails to size. Many flimsy, white, shed skins of the leafhoppers are left on the undersides of the leaves.

Fig. 14.—Injury to foliage by nymphs and adults of the bramble leafhopper.

Habits and Life-History.—The adults are greenish-yellow, wedge-shaled insects about one-eighth of an inch long (Fig. 15). The immature stages, or nymphs, are similar in shape to the adults but are wingless, very small, and pale white. Both nymphs and adults are active, and the adults may fly or jump when disturbed.

The bramble leafhopper passes the winter in the egg stage under the bark of the cane. The eggs hatch during the first two weeks in May, and the newly emerged nymphs feed on the undersides of the leaves. The nymphs become full-grown and develop wings in three to four weeks. The adults are abundant from mid-June to the end of July, when they lay eggs in the leaf and cane tissue of the fruiting canes. Another complete generation is produced from these eggs, so that by the middle of August both nymphs and adults are plentiful on the leaves of old and new canes. Adults developing from the second-generation nymphs are numerous on new canes during the first two weeks of September and may be found feeding on the foliage as late as November.

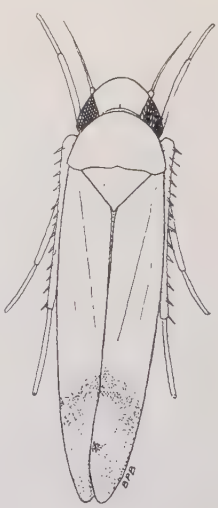

Fig. 15—Adult of the bramble leafhopper. Greatly enlarged.

Control.—In the coastal areas of British Columbia, where the bramble leafhopper is a serious pest of raspberries, the old canes should be removed and burned in late October after most of the overwintering eggs have been laid.

This leafhopper can be easily controlled with DDT, either as a 3 per cent dust or as a spray of 50 per cent wettable powder at the rate of 1½ lb. to 100 gal. of water. The 3 per cent DDT dust may be purchased ready-mixed, either with or without a fungicide such as sulphur or one of the copper materials. The dusts are usually used at 40 to 50 lb. per acre, depending on the size of the bushes. The sprays may be applied by means of a hand or a power sprayer using 100 gal. per acre. One application during the first two weeks in May has given satisfactory control, although it may be necessary to make a second application in late fall, after harvest, if the adults are numerous on the leaves of the young canes.

In the lower Fraser Valley two applications of 3 per cent DDT dust have given good control of both the leafhopper and the western raspberry fruitworm. The first application is made during the first two weeks of May, or when the blossom buds are separating in the cluster; and the second, three weeks later or immediately before blossoming.

Raspberry Cane Borers

Oberea bimaculata (Oliv.) and *O. affinis* Leng

Raspberry cane borers are widely distributed in Eastern Canada but are especially abundant in Quebec where they are the most destructive pests of raspberries. Serious injury in this province usually occurs only every second year.

Fig. 17.—Tip of raspberry cane killed by the raspberry cane borer.

Injury.—In early summer the tips of the young canes are sometimes found wilted and drooping (Fig. 17). If the cane is examined just below the withered part two rows of punctures will be found about half an inch apart, girdling the cane. The larvae bore within the pith, often killing the cane before the fruit matures the following year.

Habits and Life-History.—The adults are very slender, cylindrical beetles about half an inch long, with prominent antennae. They are black with a yellow collar, which may be either plain or bear two or three black spots. They appear in June and may be present until late August. The female girdles the cane by biting two rows of holes around it and then lays an egg between them. The larva, on hatching, bores into the pith where it feeds all season, passing the winter not far below the point of girdling. The next season the larva bores on down the cane and passes the second winter at or below the ground level. The full-grown larva is about three-quarters of an inch long. The following spring it pupates within the cane and the adult emerges in June.

Control.—In most districts all that is usually necessary is to cut off the injured tips well below the lower girdle as soon as they are noticed. Prompt removal of the old fruiting canes as soon as berry-picking is over will help greatly in reducing the infestation. Wild raspberries should be eradicated from the vicinity of the plantations.

Fig. 18.—Canes injured by the red-necked cane borer.

In plantations where other measures do not prevent serious injury, as in some parts of Quebec, one of the following sprays should be applied just before the blossoms open: (1) DDT, 50 per cent wettable powder, 2 lb.; (2) lead arsenate, 4 lb., and hydrated lime, 4 lb.; (3) Black Leaf 155, 3 lb. per 100 gal. None of these sprays should be applied after the fruit has begun to form. If it is necessary to spray after this time, derris powder (5 per cent rotenone)—5 lb., plus skim-milk powder, ½ lb.—should be applied when the last petals are falling.

The Red-Necked Cane Borer

Agrilus ruficollis (F.)

The red-necked cane borer occurs widely on raspberries and blackberries in Eastern Canada, but is seldom of much importance.

Injury.—Swellings from one to three inches long, sometimes called 'gouty galls' by growers, are found on the canes, the bark on the swellings usually being split lengthwise (Fig. 18). These are produced by the larvae feeding beneath the bark. Affected canes are weakened and may either die or produce no fruit.

Habits and Life-History.—The adult beetle is slender, elongate, and about one-third of an inch in length. It is black with a coppery-red thorax, or 'neck'. The adults are present from early June to early August; they feed on the leaves and lay their eggs on the young canes. On hatching, the young larva enters the cane and cuts a spiral tunnel about it in the wood. The cane usually swells at the point of injury. The larva which is a slender yellowish-white grub about five-eighths to three-quarters of an inch long hibernates in the pith of the cane. In the spring it pupates and the adult soon emerges.

Control.—Cutting out and burning all canes showing the swellings will usually control this insect. This should be done both when the old canes are removed after fruiting and again when the canes are thinned in the spring. Where injury is persistent, the plantations may be sprayed just before the blossoms open and again immediately after picking time with lead arsenate at 4 lb. and hydrated lime at 4 lb. per 100 gal. The lead arsenate (without the lime) may also be used in bordeaux 5-5-100.

The Rose Stem Girdler

Agrilus rubicola Abeille

The rose stem girdler is chiefly a pest of currants and gooseberries as well as wild and cultivated roses. In southern Ontario it occurs on raspberries in spasmodic outbreaks. It may be very severe one season but may almost disappear the next, probably owing to parasites.

Injury.—Beneath the bark of the canes the larvae make spiral tunnellings, which may appear at the surface like the threads of a screw (Fig. 19). The injury resembles that of the red-necked cane borer but the canes do not usually develop a swelling over the tunnels. Injured canes may die above the point of attack or may break off.

Habits and Life-History.—The adult beetle is similar to the red-necked cane borer but is uniformly dull bronze in colour. The life-history is much like that of the preceding species.

Control.—The control measures advised for the red-necked cane borer will also take care of the rose stem girdler.

Tree Crickets

Oecanthus spp.

The black-horned tree cricket, *Oecanthus nigricornis nigricornis* Wlkr., and the four-spotted tree cricket, *Oecanthus nigricornis quadripunctatus* Beut., are among the commonest pests of raspberries in Eastern Canada and the Prairie Provinces. In Quebec it has been noticed that heavy infestations of tree crickets usually coincide with grasshopper outbreaks.

Injury.—The adults insert their eggs deeply into the canes in longitudinal rows from one to four inches long. Later the cane often splits and conspicuous scars form along the rows of egg punctures (Fig. 20). Injured canes are weakened and the part above the scars may die or break off from pressure of wind or snow.

Habits and Life-History.—The adult tree crickets are whitish or greenish-white, about three-quarters of an inch in length and more slender than the common black field cricket. During late summer and autumn they lay their eggs in the canes. The young hatch the following June; they bear a general resemblance to the adults except that they lack wings. They feed chiefly on aphids and other soft-bodied insects and reach the adult stage in late summer.

Control.—When the old fruiting canes are removed after harvest, and again when the plantation is pruned in the spring, all canes showing egg scars should be removed or cut off below the punctures and burned. Any canes that do not leaf out normally should also be removed. The plantation and their surroundings should be kept free from weeds and wild raspberries.

Fig. 19.—Raspberry cane injured by the rose stem girdler.

Where sanitary measures do not give sufficient control, a spray containing 4 lb. of lead arsenate and 4 lb. of hydrated lime per 100 gal. may be applied just before bloom, and, if the infestation is heavy, again immediately after harvest. In Quebec it is advisable to spray raspberries for tree cricket control in years when grasshoppers are unusually abundant, since outbreaks of both insects usually occur together.

The Raspberry Cane Maggot

Pegomya rubivora (Coq.)

Although widely distributed, the raspberry cane maggot seldom causes serious injury except in British Columbia. All cane fruits may be attacked.

Injury.—The tips of the young shoots wilt and shrivel up. The injury is somewhat similar to that of the raspberry cane borer, but occurs earlier in the season, usually in May, and the canes do not show any external girdling.

Habits and Life-History.—The adult is a fly closely resembling the common house fly. It appears in April in British Columbia and lays its eggs singly among the unopened leaves at the tips of the young canes. When the maggot hatches it bores downward about six inches, then turns at right angles and girdles the cane by tunnelling around it. The part above the girdle soon wilts and dies. The maggot bores on down through the pith of the cane; when full-grown it pupates in its tunnel and remains there until the following spring, when the adult fly emerges.

Fig. 20.—Egg-laying scars of the black-horned tree cricket.

Control.—The injured canes should be cut off several inches below the wilted part and burned as soon as they are seen. They should also be removed when the plantation is pruned.

The Burdock Borer

Papaipema cataphracta (Grt.)

The burdock borer, one of the common stem borers in weeds and other herbaceous plants, may occasionally attack raspberries. It has been reported most frequently from Quebec.

Injury.—In late spring and early summer the larvae bore into the canes and cause them to wilt and die. The larvae are smooth cylindrical caterpillars about one and a quarter inches long when full-grown; they are brown with a white stripe down the back and another along each side.

Habits and Life-History.—The adults are yellowish-brown night-flying moths, which appear in late summer and lay their eggs on the stems of weeds and on debris on the ground. The larvae hatch the following spring and bore into the stems of plants. When fully grown they pupate within the stems. The adults emerge later in the same season.

Control.—As soon as the wilted plants are noticed they should be removed and burned. The plantations and their vicinity should be kept free of large-stemmed annual weeds.

Western White Grubs

Polyphylla perversa (Csy.)

White grubs, the larvae of a June beetle, are important pests of raspberries on Vancouver Island and parts of the interior of British Columbia where the soil is light. In recent years some growers have lost up to a quarter of their plants from white grub attack every season. The grubs are also destructive to many other crops.

Injury.—The grubs feed upon the roots, so that the canes are killed or greatly weakened. The large, stout, greyish-white grubs (Fig. 22), usually curved in a half-circle when at rest, can be found in the soil about the dying plants.

Habits and Life-History.—The adults are well known as June beetles, or June 'bugs', large brown beetles with light stripes (Fig. 21); they commonly fly about in the evening and night during late June and early July. They are particularly common around fir and hemlock trees, on the leaves of which they feed. The eggs are laid in July at a depth of 6 to 8 inches in the soil. These hatch in August and September and the tiny grubs feed on the roots of plants until late autumn, when they burrow deeper in the soil and remain dormant until the following spring. During April they come near the surface and feed upon roots throughout the summer. In the autumn they descend deeper and come up again

Fig. 21—Male (left) and female (right) of Northwestern June beetle.

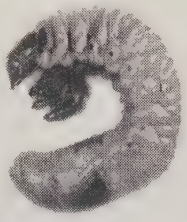

Fig. 22.—Larva, or white grub, of Northwestern June beetle.

in the spring. The third-year grubs are approximately two inches long when extended and as thick as a man's little finger. It is during the spring of the third year when they cause the most damage, just before they change to the pupal stage. The pupae transform into the adults, which emerge from the soil in late June and early July.

Control.—Two new and promising soil insecticides, BHC and chlordane give satisfactory commercial control of these white grubs in British Columbia. These materials are available in Canada under various trade names. Dusts containing BHC, 5 per cent ($\frac{1}{2}$ per cent gamma isomer), or chlordane, 5 per cent, are cheap and effective materials when used at approximately 100 lb. per acre. They should be evenly distributed over the soil and immediately ploughed in. Where small plots are to be treated, a small hand-drawn fertilizer cart or spreader can be used for applying the material. Where larger acreages are to be treated a larger fertilizer spreader drawn by a tractor, can be readily adjusted for the purpose. These insecticides are effective when applied at any time of the year and they have not caused injury to raspberry plants. Both of them appear to have a residual effect, or, in other words, remain toxic in the soil to the white grubs for more than one year. No tainting of the fruit has followed the commercial use of these materials during the past three years.

Approximate cost of the materials per acre is as follows: BHC, $10.00; chlordane, $15.00; as one application of benzene hexachloride or chlordane will control this insect for several years, the cost per year is relatively low.

Caution.—BHC must not be applied to land on which potatoes or other root crops may be grown, as it may give them an objectionable flavour.

Eastern White Grubs

Phyllophaga spp.

White grubs are found throughout Eastern Canada, and, especially in Ontario and Quebec, may seriously damage young plantations set on infested land, the large, white, curved grubs eating off the roots. Serious infestations are likely to occur only once in three years. Occasionally the adult beetles may damage the foliage to some extent.

Habits and Life-History.—The life-history differs in only a few details from that of the June beetle found in British Columbia. The adults, the familiar brown June beetles, appear in late May and June and feed on the foliage of broad-leaved trees. They lay their eggs chiefly in loose sod on light soil. The grubs

Fig. 23.—Adults of the black vine weevil (above) and the strawberry root weevil (below).

are most destructive during the second year of their life cycle. During the third year they do little feeding and soon become pupae; these transform into adult beetles during the summer but the latter remain in the soil until the following spring.

Raspberries should not be planted on land known to be infested with white grubs. Sod land should be planted with a hoed crop for one or preferably two years before raspberries are set out, but crops susceptible to Verticillium wilt, such as potatoes, tomatoes, peppers, and eggplant, should not be grown. The soil should be thoroughly disked four or five times with a heavy tractor disk before planting. Weeds such as couch grass must be eradicated.

Root Weevils

Root weevils, including the strawberry root weevil, *Brachyrhinus ovatus* (L.), the black vine weevil, *B. sulcatus* (F.), the rough strawberry root weevil, *B. rugostriatus* (Goeze), and the clay-coloured weevil, *B. singularis* (L.), are among the most serious pests of raspberries and other small fruits in British Columbia. The first three species also occur in Eastern Canada but seldom cause any serious injury to raspberries in that region.

Injury.—The white or pinkish larvae, or grubs, feed upon the roots of raspberries and many other plants. They may be distinguished from white grubs by their much smaller size, not over half an inch in length, and by their lack of legs. The adult beetles chew the edges of the leaves, causing a characteristic ragged appearance.

Habits and Life-History.—The adult weevils are hard-shelled insects, light brown to black in colour; the different species vary from one-fifth to two-fifths of an inch in length (Fig. 23). All the adults are females and are unable to fly. They feed on the foliage at night and hide in the soil about the bases of the plants during the day.

The life-histories of all four species are very similar and rather unusual in that the winter is passed in both the adult and larval stages. Adults overwintering in the soil usually emerge during mid-April in British Columbia and lay eggs on the soil during May. The larvae, on hatching, feed on the roots.

Fig. 24.—Male (above) and female (below) adults of the raspberry root borer.

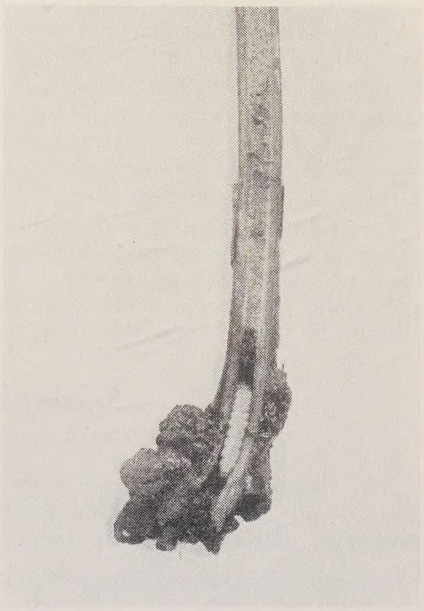

Fig. 25.—Larva of the raspberry root borer.

Some of the larvae pupate and develop into adults by late summer, but most of them spend the winter in the soil in a half-grown condition. In the spring, these overwintering larvae change to pupae and finally to adults, which emerge during June.

Control.—Weevil damage can be greatly lessened by setting out new plantings as far from old ones as possible. A crop rotation system is advantageous because a susceptible crop is less likely to be injured when it follows mangels or similar hoed crops on which the weevils do not multiply. Avoid planting after grass or clover sod. Where a plantation has become infested, the most satisfactory control is to use the following poisoned bait:

Raisins	50 lb.
Shorts	50 lb.
Sodium fluosilicate	5 lb.

Spoiled or second-grade raisins are satisfactory and often may be purchased cheaply. Low-grade figs also may be used.

Soak the raisins in 5 quarts of water for 6 to 12 hours. Mix the shorts and sodium fluosilicate together thoroughly, then add the raisins, from which the water has been drained, and again mix. Then put the bait through a butcher's meat mincer, set to cut coarsely, to form a slightly moist, crumbly mash.

Proprietary baits containing apple waste and a poison give satisfactory control.

These baits should be applied to kill the adults before they lay their eggs. Where an infestation is severe, it is advisable to apply the bait twice a year, once during mid-April, to kill the overwintering adults, and again during June, when the overwintering larvae develop into adults. To ensure good results, accurate timing of the bait application is essential. Proper timing may be accomplished at follows:

1. During mid-April. Leaves should be examined frequently for the ragged-edge effect. When ragging is observed, adults may be found in the soil at the base of the plants.

2. June 10-30. Soil about the crowns of the plants should be examined for the presence of grubs and pupae. When 80 to 90 per cent of the pupae have changed to the adult stage, the bait should be applied. The foliage also may be examined for injury during this period.

Particular attention should be paid to plants bordering on old plantings, fence rows, or sod-land where weevils are abundant. These heavily infested areas should be located early and baited to prevent the spread of weevils to the remainder of the crop-field.

One tablespoon of bait is applied per hill, care being taken to see that the mixture falls to the ground close to the canes. Where raspberries are grown in matted rows, the bait should be applied at 2 lb. per 100 ft. of row. The application should be made during dry warm weather, if possible. About 80 to 100 lb. of bait is sufficient for treating one acre.

Raspberry Root Borer

Bembecia marginata (Harr.)

The raspberry root borer occurs in all raspberry-growing areas of Canada. It is most injurious on the Pacific coast, where it appears to be becoming more destructive. All kinds of cane fruits are attacked.

Injury.—The larvae bore in the bases of the canes, crowns, and larger roots, weakening the canes and sometimes killing them. Injury generally increases as the plantation becomes older.

Habits and Life History.—The adult is a clear-winged moth (Fig. 24) with a wing expanse of about an inch. The body is marked with four yellow bands and bears a close resemblance to a wasp. Adults appear in late summer and deposit their eggs singly on the undersides of the leaves near the margin. On hatching, the young larvae crawl down to the bases of the canes. There they either excavate a cavity or enter a crevice in the bark, remaining there over winter. The following spring they bore into the bases of young canes, where they feed during the summer, girdling them and causing swellings at or below the surface of the crowns (Fig. 25). The larvae remain in their burrows over winter and reach maturity in July; they are then whitish caterpillars with a brown head, about three-quarters of an inch in length. They burrow a short distance upward in the canes and pupate. The adults emerge later through a hole near the base of the cane.

Control.—No really satisfactory means of controlling this pest is known. The removal and burning of all wilting canes during June and July is of some help. These canes should be cut off as close to the ground as possible. Sprays of 0.5 per cent summer oil emulsion have been reported to be effective in New Jersey. They should be applied at two-week intervals, the first one during the first two weeks of September.

Old, badly infested plantings should be ploughed up in late fall or early spring, and the canes and crowns gathered and burned. The removal of the plants at this time prevents the moths from infesting other plantations.

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